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The Design of Standardisation Processes in ICT: An evolutionary transaction cost approach

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April 1999

Abstract As transaction costs have become an increasing part of the economy's overall costs, reducing transaction costs has become increasingly important in economic organisation. An example where this is pertinent is the organisation of standardization processes in, notably, Information and Communication Technology industries (ICT). The processes that generate and select standards need to adapt to better solve the trade-off between facilitating innovation and reducing transaction costs. The Internet plays an important role in this regard. This paper explores a dynamic version of transaction cost economics and population ecology to analyze hybrid market / negotiated selection of standards in various ICT cases: Internet browsers, the DVD, IP telephony, handheld computers, and the Linux operating system.

Keywords: organisation of standardisation, transaction costs, information and communication technology

JEL codes: L14, L22, L63, L96

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INTRODUCTION

In Information and Communication Technology industries (ICT, for short), standards play an important role. The development and selection of standards is a process of coordination. In many cases, the efficient outcome is where all parties involved coordinate on one standard. How do firms, their customers, and other stakeholders in this process organise this coordination? Do coordination failures occur? What lessons have been learned, and how do standardization processes adapt?

This paper looks at standardization from a transaction cost perspective. Can we learn something here? The aim of this paper is to develop hypotheses about the choice of and coordination failures incurred by standard development and selection processes. Several case studies help to develop the argument, notably, browsers, the DVD, handheld computers, IP telephony, and the Linux operating system.²

STANDARDS

We begin with a definition of standards, in order to make clear from the outset what the topic of the paper is. Tirole's (1988, p. 405) classic textbook defines a standard as 'a choice of a particular technology to be adopted by everyone'. That is, a technology is a standard if it is (socially) efficient if everyone adopts it instead of any other competing technology. Network externalities explain this efficiency: 'Positive network externalities arise when a good is more valuable to a user the more users adopt the same good or compatible ones.' (ibid., p. 405). The externality can be on the demand side, a direct network externality, when each user benefits if other users use the same technology. Examples are telecommunication networks, languages, and transport networks. The network externality can also exist on the supply side, an indirect network externality, when there are economies of scale in creating (developing, producing, or marketing) a product or service. The more users use this product, the more costs fall or quality increases, due to the economy of scale.

Two technologies are compatible if their combined utilisation gives rise to a positive network externality, that is, they serve as one standard mentioned above. If they are not compatible, it can still be possible to realise a demand side externality. The solution is to create a bridge between two different products or networks, such that users can benefit from their joint use of these products or networks. For example, a computer and a telephone network are substantially different products, but the invention of the modem allowed users to connect their computers to each other via the telephone network. A gateway can connect the Internet to a telecommunication network for an Internet telephony service. Adapters (such as a modem), gateways, and routers connect two different technologies such as to create a positive network externality for their users.

To create a positive network externality we can do two things, therefore. We can create a standard. Or we install a costly interface, adapter, or gateway, if at least, the network externality exists on the demand side. The advantage of a standard is that we realize supply side externalities or that we economize on the costs of the interface, adapter or gateway. This is why standards are efficient. Selecting a standard is, however, also costly: there are, perhaps considerable, organisational, social and economical costs involved in developing and selecting a standard. To put it differently, the organisational costs of standard selection should not outweigh the resource costs of installing gateways and the like.

TRANSACTION COSTS

The theory of transaction cost economics defines *transaction costs* as 'the costs of human coordination and cooperation' (North, 1996), or, 'transaction costs are costs of running the economic system' (Arrow, 1985, p. 501). Arrow identifies various sources of transaction costs: exclusion costs (costs to exclude non-buyers from consuming the good), costs of communication and information, and costs of disequilibrium, as transactions occur before the final equilibrium is computed or they are delayed until

² The source of the cases and the examples in the text is a relational database on cooperation and standard setting that I constructed on the basis of information from various sources. These sources include business and ICT journals *Automatisering Gids*, *Business Week*, *Byte*, *Computable*, as well as various business information sources (annual reports, etc.). Most data cover the period 1995 to recent.

that moment. Exclusion costs include the protection of copyright, patent, and trademark against hacking, criminal access, and non-paying free-riders. In other words, transaction costs consist of the costs of getting information and monitoring, motivation and contracting, and excluding non-payers.

Transaction cost economics argues that individuals choose that particular organisation form for their transaction that minimizes transaction costs (Coase, 1937; Williamson, 1975). This approach is a form of comparative statics. In other words, from among a given menu of organisation forms, people involved in a transaction choose the efficient one. This assumption is, however, questionable.

- If firms 'strategize' they do not 'economize' (see Williamson, 1991). A profit maximizing firm only tries to reduce its own transaction costs. It has fewer incentives to reduce its customers' transaction costs, and it has no interest in reducing transaction costs of its rivals. It may pursue a strategy to raise transaction costs of rival standards, products or technologies. An example is the FUD (fear, uncertainty, doubt) strategy by market leaders IBM and Microsoft. By casting doubt on the survival chances of their rivals, they force these rivals to incur costs to convince their buyers that they will still be around in the near future.
- Transactions occur in a context, an atmosphere, that has a value in itself rather than being an instrument to minimize transaction costs. There are social norms, routines, and objectives involved in the choice of transaction mode.
- If people are boundedly rational, as transaction cost theory assumes, then they may well be unable to correctly select the cost minimizing organisation form. For one thing, measuring transaction costs is no easy matter.

If people are not able to select the cost minimizing organisation form, they may perhaps learn over time which organisation form best suites a particular transaction. This suggests that we need a dynamic approach, where changes in transaction forms occur to reduce transaction costs over time. I suggest to construct a dynamic transaction cost theory in two steps: the innovation of new transaction (organisation) forms, and their diffusion. The table gives hypotheses for factors that explain the innovation and diffusion of transaction forms.

Factors that stimulate (+) or impede (-) the innovation and diffusion of a new transaction form		
	Innovation	Diffusion
Diversity of personal preferences and views	+	-
Vested Interests		-
Pockets of communities	+	-
Migration of people, spreading of ideas, products	+	+
Legitimation	-	+
Freedom of speech, organization	+	+
Commitments (inertia, long-term contracts)		-
Reputation	-	+
High transaction costs	+	?

Table 1: New transaction forms

(1) Innovation: How do new transaction forms emerge?

Proposition 1a: New transaction forms may originate in outside fields:

- Pockets of communities with unique personalities, ideas or cultures
- Different countries or markets, connected by migration of people or ideas

(See the table above)

Society may look down upon communities outside of its mainstream. In a market economy, governmental institutions such as universities are, for instance, considered bureaucratic and inefficient. They may well be, from an operational and static point of view. The same may hold for communities such as the Amish in the U.S., hippies, etc. In a dynamic setting, however, these groups may stumble on ideas that may change their society for the better. Universities, for example, spawned the Internet

and the Linux operating system. This may be one example, where Schumpeter (1976) was right in conjecturing that

“A system -any system, economic or other- that at *every* given point of time fully utilizes its possibilities to the best advantage may yet in the long run be inferior to a system that does so at *no* given point of time, because the latter’s failure to do so may be a condition for the level or speed of long-run performance.” (p. 83)

An (isolated) community that is inefficient, at least by the standards of society at large, can over time be source of new ideas that help that same society forward. The same may hold for different countries or industries: an ideosyncratic way of doing things in one country or market may eventually spread to other places, where it is a source of organisational innovation.

(2) Diffusion: How do new transaction forms spread?

Proposition 1b: If some established players accept a new transaction form, they give it legitimacy, which stimulates its diffusion.

(See the table above)

Legitimacy can be shortlived, if the established players got it wrong. Even successful established players are boundedly rational. Opportunism may compromise their judgment. Subsequent events may not bear out the efficiency of a new organisation form. In the long-term, at least in a market economy, it will tend to be the performance (real transaction costs) that will, as transaction cost economics predicts, determine which organisation forms prevail.

Before we link these notions of a dynamic transaction cost theory to the organisation of standardisation, we first discuss the organisational choices that can be made in standardisation.

STANDARD SELECTION MODES AND TRANSACTION COSTS

The aim of a standardisation process, and the criterium by which it needs to be judged, is twofold:

- (1) Develop and select the best standard, that is, the one that (over its lifetime) will generate the highest value for society as a whole (the stakeholders);
- (2) Organise this process of standards development and selection at the lowest transaction costs.

If a standardization mode meets these two criteria, we may call it efficient. To see an example, consider the market selection of operating systems for personal computers. Was this process efficient? No, say those who believe that the dominance of the Windows OS over the Macintosh and OS/2 is inefficient. It may well be, in terms of the first criterion. But look at the second criterion. The transaction costs of interacting with Apple are huge. Apple has a solid reputation of destroying trading partners. Witness its Newton handheld computer; witness its aborted licensing scheme of the Macintosh OS. It does not, except for the brief period just alluded to, license its OS. From a transactional point of view, Microsoft may have been the most efficient winner. If either Apple (with its Macintosh) or IBM (OS/2) would have won the battle, would so many people now enjoy the use of a PC? Would PCs offer the same quality as they do now, for their low prices? Whether this argument stands rigorous testing is a moot point, but what really matters here is to demonstrate the value of using both criteria, when evaluating the efficiency of the a particular selection mode of standards.

This paper is about developing a framework to postulate hypotheses about the process of standardization, the mode of standard development and selection. A framework for standardisation processes needs to explain the organisational design features of a standardisation process. The following questions refer to the most important aspects of organisation design:

- Is there one coordinating body for a particular technology or function or are there several competing ones?
- Is this a permanent, institutionalized, body, or rather a forum of organisations and individuals?
- Does the body deal with a specific function or standard, that is, is it a one-issue effort, or does it deal with various functions, technologies, and standards?
- Does negotiation occur over individual technologies or standards (modules) or over the architecture of a modular system or an entire system?³
- Do vendors dominate the membership and voting rights of a coordinating body?
- Which vendors / users / etc. participate in the collaboration?
- Which aspects of standardization are negotiated or done collectively? (Distinguish development, drafting, selecting, and documenting, implementation, operability testing, marketing, and integrating user feedback)
- Does the standard setting organisation own patents and other property rights? Do vendors transfer patents and other property rights to a standardization body?
- Are the standard proposals binding for the members?

These lists of organisational choices that need to be explained, and their possible determinants, represent a research proposal. In the context of this paper, only some possible combinations of determinants and organisational choices can be shown.

DESIGNING THE MODE OF STANDARDISATION

This paragraph will discuss how various aspects of the organisation of standardisation processes emerge as an outcome of various determinants, notably, decreasing transaction costs, convergence, and business strategies. A collection of propositions summarizes the features explained by these determinants. We can summarize our argument in figure 1.

³ See Henderson and Clark (1990) for architectures and modular innovations.

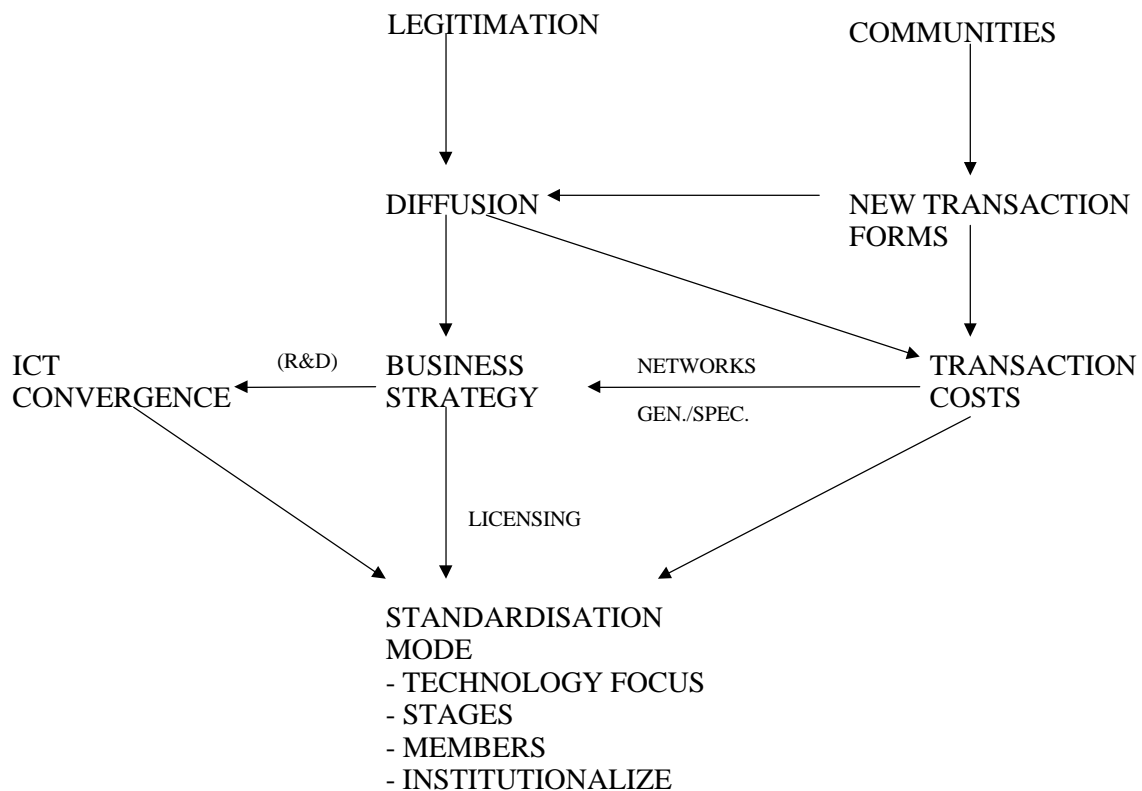


Figure 1: Determinants of the Standardisation Mode

In studying the mode of standardisation, we look at three aspects: (1) whether there exist one or more coordinated, joint standardisation efforts, (2) the boundaries or scope of a joint effort in terms of the standardisation process in the market, and (3) the internal organisation of the joint effort.

Central coordination of the standardisation process

The first design question to address is whether there is a joint cooperative effort to set standards? In the case of market selection of standards, private firms develop technologies which they try to support into becoming the standard by selling products in the market that are based on the standard.

The (dis)advantages of a joint coordinated standard selection effort include:

- If there are competing technology standards in a market, investments by technology users are standard-specific, which is a form of asset specificity. If a joint effort specifies a standard, users forego the (switching) costs of investing in the wrong (ex post) standard. With less uncertainty among users which standard will evolve, investments and growth of the market accelerate: standards grow the pie for all organisations involved.
- If there are competing technologies in a market, the advantages of having a single technology (the network advantages) are (temporarily) lost. Hence, the larger the network advantages, the more likely that firms want to cooperate in standardisation.
- A centrally coordinated effort can include technologies and other input from various suppliers and buyers. This feature gains importance if the complexity of products and technology systems increases.
- A disadvantage consists of the organisational costs of firms and others to set up and participate in a joint coordinated effort. These costs include monetary costs, as well as delays. The Internet

serves as a cooperation medium that has reduced these costs, in particular by speeding up communication and information exchange.

- If a joint coordinated effort licenses a technology standard, licensees may be less afraid for opportunistic renegotiation than when a private firm would license a technology. To reduce the transaction costs associated with licensing contracts, a firm may well hand over its technology to a joint coordinated effort. It then gives up some control over the technology itself, and its licensing policy. If its technology is included in a standard, it will earn a licensing revenue from customers who need not be afraid that the firm will opportunistically change its licensing policy. Hence, it trades off some proprietary control over its technology as a price to pay for allaying potential customers' fear for opportunistic maltreatment.
- If a business strategy focuses on proprietary technology, the firm is likely to see loss of control as a disadvantage of a joint coordinated standard selection effort. By a *proprietary technology* we mean that the firm has control over the technology itself, or over the conditions under which it makes the technology available to others. If, instead, the technology is an input for or complement to activities, and the firm derives its competitive advantage from those activities, it may well welcome a joint coordinated effort to develop or standardize the technology. Hence, the role of proprietary technology in business strategies is a determinant of the development of joint coordinated efforts.

These arguments suggest the following:

Proposition 2: The following conditions stimulate the development of a joint coordinated standardisation effort:

- Switching costs of technologies
- Network advantages of a common technology
- Complexity of the product or the process
- Decreasing costs or increasing speed of collaboration
- Transaction costs of licensing contracts make private licensing less attractive, and a joint coordinated licensing policy more attractive
- Business strategies that treat technology as a complement to their competitive advantage, rather than as the source of it

Within a standardisation process, there may emerge several joint coordination standardisation efforts. We will discuss various reasons for that. One is that it may be a form of division of labour. Specialisation has the disadvantage that it requires transactions between specialised suppliers, which creates transaction costs. If a combination of technological and organisational innovation (and diffusion) lowers transaction costs, this indirectly stimulates specialisation. A development that lowers transaction costs (an ICT technology, like the Internet, or a new organisation form) enhances the ability to create division of labour. The coordination problems when there are many specialists, may create a role for coordinators, integrators and organisers. Vendor consortia and other standardisation bodies develop into specialists, with complementary functions to businesses and users. We may even surmise that among standardisation bodies a polarisation occurs between generalists, like the ITU, that standardise architectures, and specialists, such as the IrDA (InfraRed Data Association), that standardise modular technologies. See table 2 in the appendix for a list of standardisation organisations that this paper refers to, the abbreviations they are known by, and their activities.

Proposition 3: Low transaction costs increase division of labour, leading to specialised standardisation bodies

This proposition offers one explanation for the increasing number of highly specialised standardisation bodies.

Participants in the standardisation process

Convergence of the technological basis of ICT industries means that companies from different markets (telecom, consumer electronics, etc.) benefit from common technologies. They want to be involved in the development of standards. Convergence therefore tends to increase the number of parties that try to get involved in standard setting.

Low transaction costs, lowered by the telephone, fax and Internet networks, improve communication between people within and across companies. One of its consequences seems to be a growing diversity of the sources of creativity, innovation, and know how. There is a trend that large companies scale down their central R&D office, while decentralising the R&D effort to divisions or subcontractors. This may improve accountability and performance of R&D work. It may also, however, be a response to a perceived trend towards a more dispersed source of creativity. Knowledge integration gains importance. Standardisation bodies play a role here: by developing standards, they allow new and existing components to be combined into new goods and services.

If we combine these consequences of low and decreasing transaction costs, and convergence between ICT industries, we may conjecture:

Proposition 4: In the case of decreasing transaction costs or industry convergence, more parties (with a heterogeneous background, in terms of industry and country) try to get involved in the standardisation process.

Stages in the standardisation process

With dispersed sources of creativity, the difficulty increases of coordinating technological development. The R&D research lab is the traditional organisational (transaction cost reducing) solution: bringing people in one location facilitates coordination and communication. In the case of standards, however, coordination needs to go beyond the company's boundaries. When companies integrate their technological knowledge and commercial needs, they face two conflicting imperatives: to include all relevant ideas and interests, while limiting the coordination costs. How do they solve this problem?

Proposition 5: Conditions that increase the coordination costs of a centrally coordinated standardisation mode tend to induce the standardisation process being split up in stages, such as technology development, selection, interoperability testing, or promotion, with specialist institutions per stage.

One of the advantages of splitting up the standardisation process is that the organisation of standardisation can be optimised per stage. The organisation can be adapted to the kind of people or institutions involved, the number of participants in the process, the kind of information that needs to be exchanged, legal or policy requirements, etc. In the technology development stage, the number of companies involved may be small. The form they choose for their organisation is often a joint venture or a forum. In the selection stage, users will want to play a role. This increases the number of participants, often into the hundreds. The organisation form preferred for this situation tends to be a membership organisation. Membership fees can be differentiated for different types of members. Small firms or individual people may have smaller membership fees to pay than large companies or governments. They may also have fewer voting rights.

A staged process occurs if one or more vendors develop a technology, and then submit it to a standardisation body. The latter then rubberstamps the standard. Cooperation with established bodies can give private business enough clout to influence the direction and speed of standard setting, while the official standard setting body sanctions their work. The standard setting body can gain from a working relationship with private standard setting alliances by outsourcing some technical work to these private activities. Moreover, the support by industry increases the chance that a standard agreed upon is actually used in practice.

For instance, Microsoft ceded part of its control over ActiveX to the ActiveX Working Group, which is a part of The Open Group, an industry standards-setting consortium. Until now, someone who wants Microsoft to certify its use of ActiveX has to reveal its product's secrets to Microsoft. Microsoft

alleviates this fear (a source of transaction costs) by giving up some control to the ActiveX Working Group. As an open standard, ActiveX should see broad industry support.

Pressure groups by users may not contribute to developing standards, but try to influence the process. Browsers are a case in point. Browsers adopt standards set by the W3C, the World Wide Web consortium, but they may also include some innovations developed by the maker (Netscape, Microsoft, Sun). Consumers and makers of websites may or may not like these new features. The W3C may or may not adopt it. On that basis, the software developer can adapt his browser. If he drops some features, this may harm makers of websites that used them. Among the standards that browsers (should) adopt are the HTML language. The anybrowser.org and the WIP (Web Interoperability Pledge) try to coax makers of websites to adopt HTML standards agreed by the W3C, and to reject HTML codes by Netscape, Microsoft, or other software makers, that are experimental, firm-specific, and not endorsed by the W3C. The WSP, Web Standards Project, and The Open Group cooperate to develop tests for standards compliance of websites.

Focus of a standardisation initiative

Convergence of the technological basis of the ICT industries suggests that coordinating standards on a per-industry basis loses its relevance. We may conjecture:

Proposition 6: Convergence (of markets and / or technologies) induces standardisation institutions to switch from a market focus (e.g., telecom) to a technology focus (e.g., memory cards, or infrared data transmission)

If it chooses a technology focus, this raises the problem: how focused should the standard setting consortium be, in terms of topics addressed? If too focused, other groups may develop related, and then incompatible, standards. It may then have to cooperate with them to prevent this. For instance, the WAP forum and the World Wide Web consortium face the need to cooperate on giving wireless terminals access to the Internet. The IMTC is a merger of three separate standardisation groups. If it chooses its topics too broad, the standard setting consortium spreads itself wide, costs go up, bureaucratization emerges, and speed to market of a new standard may slow down.

These propositions 4, 5 and 6 show that collective standardisation initiatives need to define their boundaries in terms of (1) the membership it seeks (vendors, user firms, government, individuals), (2) the stages of the standardisation process it wants to coordinate (standard selection, or also development, or interoperability testing?), and (3) the range of technologies it wants to cover.

Institutionalize cooperation and standardisation

We have now discussed the existence of a joint standardisation effort, the boundaries of such an effort, and will finally turn to the third aspect of the design of the standardisation mode, namely the organisational design of the central coordinating agency. Coordination may take the form of a forum, committee, or informal alliance. Businesses may, however, also institutionalize their cooperation in standard setting by choosing more durable designs. Rules, reputations, and conflict resolution schemes are instruments to punish opportunism by the alliance relative to customers, or by individual participants. The IrDA is for example a separate institution with the sole objective of developing infrared technology for computers and peripherals. This objective reduces its dependence on individual companies, such as Hewlett-Packard, which dominate in the market for peripherals that support IrDA.

A semi-permanent alliance has to balance durability with flexibility. It needs to be flexible, for if it wants to attract new members, it may have to change the rules if they want that. (For example, partners from the open source movement want software to be released as open source). If it is inflexible, potential members may create their own show. In terms of durability, some business consortia begin to develop similar features as the earlier, government-endorsed standardisation institutions (institutional isomorphism, DiMaggio and Powell, 1983):

- They increase the scope of their topics (to prevent other institutions from doing similar, but perhaps, incompatible work in related fields). See how the ITC spreads toward convergence between telecommunication and the Internet, or how the PCMCIA spreads to smaller card formats than the PC Card.
- They become more durable, to build up reputation.

Subsequent to the choice whether or not to institutionalise, is which organisation form to choose. If the partners create a joint venture (JV), they are in control. The share a firm has in the ownership of the JV affects the extent to which it is in control. The partners control who, if at all, can join their alliance. If the partners choose a membership organisation form instead, they determine the conditions under which they allow new members, the rules and procedures. They can no longer directly determine whether or not someone else will join the organisation. A membership organisation form gives the alliance itself a large degree of operational independence. This is more conducive towards extending the alliance to new participants than the JV form.

The choice of the degree of institutionalisation and of the organisation form lead to transaction costs. These transaction costs include the following:

- Membership fees of organisations for standardization and other forms of collective action
- Coordination failures, e.g., due to competing standard setting organisations (LSA and LSB in the Linux community; ITU and IETF in IP telephony)
- Moral hazard by participants, for example:
 - Participation for monitoring rather than contribution
 - Participation to slow down the cooperative effort if, for example, the adoption of an industry-wide standard would hurt the profitability of a firm
 - Participating in multiple alliances with incompatible aims
- Communication failures in cooperation, such as lack of communication, misinterpreting intentions

Legitimate the standardisation initiative

Apart from making appropriate institutional and organisational choices, a new joint standardisation initiative needs to legitimate itself (see proposition 1b). Without legitimacy, it will not attract members and funding, and its proposals for standards will be ignored. How does a standard-setting organisation legitimate itself? The following means are in use:

- Government endorsement (e.g., ITU, ETSI and other telecom bodies)
- Market leaders participate: think of AT&T, Cisco, IBM, Intel, Matsushita, and Microsoft, as leading members.
- Build a tradition in a certain field. A permanent institution can gain legitimacy over time. This speaks in favour of permanent, institutionalized forms of cooperation. Rather than a loosely-nit alliance, make a consortium, for instance, with a separate organisation.
- Give the consortium assets, such as the property right of the standard proposed.
- Create an anti-Microsoft alliance (e.g., Netscape browser, Java, the Network Computer, Linux)
- Cooperate with other standardisation bodies on common areas

Coordination failures in a decentralized standardisation process

New forms of standards battles and coordination failures occur, for various reasons, including the development of competing standard setting organisations. If a collaborative effort develops and controls an architecture, various competing standard setting bodies may emerge, in order to appropriate the revenues. An example is the competition between the LSB and the LSA for the Linux operating system, and the PCMCIA association versus the Compact Flash Association, CFA, for very small data storage devices for handheld computers (respectively, the Miniature Card and the Compact Flash). Several arguments of this section can be summarized in the following:

Proposition 7: The following conditions may give rise to (+) or impede (-) a standards battle between joint standardisation efforts:

- A narrow definition of the (technological or market) scope of the joint effort (+)
- Newly established joint efforts may not have enough reputation to ward off competing efforts (+)
- Opportunistic business strategies (moral hazard) may give rise to competing joint efforts (+)
- Government endorsement of a joint effort may ward off competing joint efforts (-)
- Participation by market or technology leaders in a joint effort may ward off competing joint efforts (-)
- The existence of incompatible technological concepts, systems or paradigms can give rise to competing joint efforts (+)
- If considerable intellectual property rights are associated with competing technologies, this can stimulate competing joint efforts (+)
- The conditions imposed on participants or members may not appeal to all potential members (+)
- The consequences of the not invented here (NIH) syndrom and egoistic empire building (see Jordan Hubbard, <http://editorials.freshmeat.net/jordan980713/>)

Even in a setting with negotiated joint efforts, coordination failures can arise, therefore. How do firms try to solve or exploit these coordination failures?

- Invent a technology oneself and submit it to a benign standard setting organisation
- Work around standard (setting) by linking components in a stop-gap way, developing gateways, adapters, interfaces, etc.
- Proprietary technology for customer-specific network
- Sell product now, upgrade to standard later
- Undercut collaborative efforts
- Join or create competing process

How do the standardisation bodies themselves try to solve these problems?

- Mergers occur between standardisation initiatives with overlapping focus areas (e.g., The Open Group is the outcome of various mergers, and so is the International Multimedia Teleconferencing Consortium, IMTC)
- Alliances between them. Work out productive, complementary relations
- Create a division of labour between standardisation initiatives. A division between generalists (such as the IETF, ITU, and the W3C) and specialists (such as the IrDA, PCMCIA, and many others) may occur
- A dual mode of operation, consisting of permanent institutions, with ad hoc teams doing the actual work, consisting of people from various standard setting bodies, if relevant
- Speed up decision making about standards
- Define a framework for the new standard, let the market (suppliers) hammer out the details

In this paragraph we have discussed the organisational design of the standardisation process as a whole, as well as the design of the central coordinating agency of a joint coordinating effort. We now turn to some case studies that illustrate various aspects of this discussion.

SOME CASE STUDIES

Case studies offer opportunities to put our ideas to the test, as well as to develop our framework. They cover hardware (the DVD and handheld computers), software (IP telephony), services (IP telephony), and media (the DVD). In the context of the ICT industries, they cover consumer electronics (the DVD), communication industries (IP telephony), and computing (DVD and handheld computers).

DVD and the ZIP drive

The CD-ROM and its designated successor, the DVD, is a digital data storage medium. And so is the Zip drive, one of several competing successors to the floppy disk drive. The capacity of the DVD is much larger than that of a Zip disk, but on a Zip disk the user can store data, and this is not yet possible with the DVD, which is only for reading data. Notwithstanding their similar functions, the processes for developing a standard for them have been very different.

In the case of the DVD, there were two groups of developers, each with its own technology. The SD group (Super Density CD) consisted of Toshiba, Pioneer, Thomson, and Matsushita. A competing technology, the Multimedia CD-rom, came from a 3M, Philips and Sony (the MMCD group). To avoid forcing the users and the supporting media and computing industries to choose between these two incompatible technologies, these two groups merged. They formed the DVD Forum to hammer out a common standard.

This is not how things went in developing a successor for the floppy disk. For a high capacity successor to the floppy disk, there are various competing alternatives available in the market. Iomega's Zip drive was the first to become successful. Its storage capacity of 100 Mb is much larger than the 1,44Mb of a floppy disk. Compaq, Matsushita and 3M developed an alternative disk, the LS-120, with a slightly larger storage capacity of 120 Mb. The LS-120 is backwards compatible with the 3.5" floppy, that is, a LS-120 drive can read a 3.5" floppy. The Zip disk is not compatible with the LS-120 nor with the 3.5" floppy. Since both products are already in the market, the customer will decide which standard will dominate.

Why did the developers of the DVD create a joint platform to develop a unified format (a negotiated standard selection process), and did the manufacturers of new floppies turn to the product market to select a standard? The following factors may have played a role.

- All DVD / SD / MMCD proposals are (physically) compatible with the CD(-ROM), and backwards compatible with the audio CD, photo CD, CD-ROM, and Video CD. So there is a strong common technical basis on which to build a compatible new format that embraces many ideas of the competing fractions. This is not so with the new floppy: the Zip drive is not compatible with the 3.5" floppy disk, unlike the LS-120, so there is no technical basis to hammering out a common proposal.
- The data to be stored on a DVD come from media companies, who want one format to work with. This turned out to be a compelling form of user pressure. The data on a floppy disk mostly come from the individual PC user, who may use it mainly for data backup, or for data exchange between computers. As a medium of data exchange between people, the floppy has lost importance to the Internet. With a decreasing network externality, it is less important to select a standard for a floppy. Provided, of course, that sales of each disk drive system are enough to generate economies of scale in production.

The expected revenues from the DVD system are much larger than from a new generation of disk drives. This is related to the DVD as carrier of new media (for games consoles, video players, and multimedia encyclopedias). Hence, there is more willingness to establish a joint standard setting forum (the growing-the-pie argument). Floppies and disk drives are a low margin business, where a supplier as Iomega is more concerned with expanding its hold over the market segment for supper-floppies (the sharing-the-pie argument).

The competition between the SD group of Toshiba, Pioneer, Thomson, and Matsushita, and the MMCD group, of 3M, Philips and Sony, shows that the battle for control over standard setting shifts from a battle between individual players (market selection of standards) to a battle between alliances (negotiated selection of standards) (see proposition 7). The plethora of standard setting initiatives creates new forms of transaction costs for technology providers and users. User pressure can force these vendors back into line, as happened when pressure by computing and media firms ushered in the DVD forum.

IP telephony

Internet telephony, also known as IP telephony or Voice over IP, started in 1995 when the software company Vocaltec introduced a program for communicating over the Internet by voice. Instantaneous communication by exchanging typed sentences over the Internet already existed ('chat'). What Vocaltec added was the instantaneous exchange of voice signals instead of typed text. Vocaltec used the chat infrastructure to exchange a different data type: speech instead of text. Both data types can be digitized and, once translated into digital format, they can be transported by the IP protocol over the Internet network. Hence the expression 'voice over IP'.

Software makers, such as Microsoft and Netscape, were quick to develop their own Internet telephony program or browser-plug in. Internet service providers realized that this program adds a new functionality to their clients, while it also will increase the need for bandwidth by their users. Data communication operators see Internet telephony as a factor that will increase demand for their network capacity. Telecom operators began to understand that Internet telephony would help them in their data communication department, but would hurt them in that it might develop into a low-cost (and low-quality) substitute for their own plain old telephone system (a.k.a. POTS). Convergence led to a large variety of firms who want to participate in standardisation of Internet telephony, which illustrates proposition 4.

The parties that want to help Internet telephony further, want to make sure that anyone who uses program A to phone over the Internet can communicate with anyone using product B or C. This calls for a standard. The ITU developed an architecture for Internet telephony, called H.323. H.323 addresses the complete infrastructure needed to provide a high quality Internet telephony service. Many private companies have done the R&D to develop the technologies needed for an H.323 Internet telephony service. Some industry alliances work on the interoperability between various Internet telephony products as well as on the interoperability between telecommunication (POTS) and voice over IP. An example is the Voice over IP Forum (VoIP), which intends to improve the interoperability of IP telephony products. This division of labour is a nice illustration of propositions 3 and 5.

The control by the ITU over the H.323 standardisation process is not entirely without friction. The Internet Engineering Task Force, IETF, traditionally controls standard setting in the Internet. It has its own activities pertaining to standards for secure transmission of multimedia data over the Internet. To avoid problems as intimated by proposition 7, the ITU recently acknowledged the IETF as an official partner in standard setting. The importance of the H.323 architecture for computer companies has been a stimulus for the ITU to speed up its pace of standardisation, although its speed may still not be up to "Internet time" (where new developments occurs in quarters instead of years). It also means that computer companies become acquainted with the collective and careful process that is standard in telecommunication. This illustrates proposition 1a, with an exchange of developments between the telecommunication and the Internet / computing / data communication industries.

Portable and Handheld Computers

The first generation of handheld computers could exchange data with a PC or printer via a cable. The latest generation has a wireless technology for data exchange based on infrared light. Infrared light technology is an alternative, that allows a handheld computer to send or receive information with other hardware that has a compatible infrared connection. The advantage of infrared over cable is that a cable is a separate component that the user may loose or forget. An infrared module therefore increases the out-of-the-box connectivity of the handheld computer. However, this does require a standard that defines how data are (de)coded and transported via infrared light.

Vendors of PCs, portable computers and peripherals created an independent organisation, the InfraRed Data Association or IrDA, to develop this standard. The IrDA has a strong network advantage: the more computers and peripherals can send and receive an IrDA infrared signal, the more useful it is to have a machine equipped with IrDA. This suggests that there are strong advantages to coordinating on the development of this technology. Another reason for firms to lay standardisation in the hands of an industry-wide consortium is that IrDA is a module that has no potential to develop into an architecture. Firms with architectural control in the markets for portable and handheld computers and their

peripherals, such as Apple, Hewlett-Packard, or Microsoft, faced no loss of control when adopting the IrDA standard.

The IrDA organisation is an example of proposition 3, the development of separate standardisation bodies with a specialised function. It also is an example of proposition 6, that new standardisation bodies tend to focus on technology rather than a particular market. While the infrared technology was originally thought to be useful for portable computers and printers, in the newly converging telecom and data communication environment, it works for connecting handheld computers to digital mobile telephones.

The direct network advantages in the DVD (as a media), Internet telephony and the IrDA show the relevance of proposition 2.

APPRAISAL

Suppliers, users, and governments constantly face questions about how to organise a process of standardisation. It seems as if each time, they come up with a slightly different answer. People, firms and governments grope towards new ways of combining market processes and negotiation. A combination of seven propositions has been shown to be able to explain at least some design features that emerge in the ICT industries in the 1990s. Convergence in the ICT industries is also an institutional process: new standardisation processes and institutions try to integrate elements of standardisation processes in computing (e.g., speed and being market-driven), telecom (rigorous testing), and the Internet (being open and user-driven). Transaction costs arguments are very useful in predicting organisation choices. Transaction cost economics is less successful in explaining why and how new organisation forms appear. We need to go from statics (choice of an organisation form from a menu of alternative organisation forms) to dynamics (the design of new organisation forms). We sketched a dynamic restatement of transaction cost economics that gives pointers for future theory development. Three case studies illustrate the relevance of these propositions. For rigorous testing we will need more finegrained data than currently available.

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Appendix: Standardisation organisations

Name	Full name	Case study	Aim
Anybrowser.org		HTML, browsers	Make editors of websites adopt industry (W3C) standards for HTML
CFA	CompactFlash Association	Handheld computers	non-profit organisation to promote the worldwide adoption of CompactFlash as a miniature data storage standard
DVD Forum	Digital Video Disk forum	DVD	Develop standards for DVD video, DVD-ROM, DVD-RAM, etc.
ETSI	European Telecommunications Standards Institute	IP Telephony	Develops and supports adoption of standards
IETF	Internet Engineering Task Force	IP Telephony	Develops TCP/IP and other standards
IMTC	International Multimedia Teleconferencing Consortium	IP Telephony	Focuses on promoting standards for multimedia communications by doing interoperability test sessions
IrDA	InfraRed Data Association	Handheld computers	Create and promote infra-red data communication
ITC	Internet Telephony Interoperability Consortium	IP Telephony	An initiative from the MIT to specify middleware for Internet telephony
ITU	International Telecommunications Union	IP Telephony	Official standard setting and regulating body for telecommunication worldwide
LSA	Linux Standards Association	Linux	First initiative to create a standard setting organisation for Linux
LSB	Linux Standard Base	Linux	Competing standard setting organisation for Linux
MMCD	Multimedia CD	DVD	Develop a high-capacity successor to the CD-ROM
PCMCIA	Personal Computer Memory Card International Association	Handheld computers	Develop (standards for) small, portable computer data storage devices
SD Group	Super Density alliance	DVD	Develop a high-capacity successor to the CD-ROM
The Open Group		Browsers	Develops standardisation for Unix, the Internet
VOIP	Voice over IP forum	IP Telephony	Improve the interoperability of Internet telephony products on the basis of H.323
W3C	World Wide Web Consortium	HTML, browsers	Develop standards for the World Wide Web (an application of the Internet)
WAP forum	Wireless Application Protocol Forum	Browsers	Standards for wireless information and telephony services on digital mobile phones and other wireless terminals
WSP	Web Standards Project	HTML, browsers	Make software producers adopt industry (W3C) standards for HTML
The column 'case study' refers to that case study where the organisation plays a part. The organisation may have many other activities as well.			

Table 2: Standard setting organisations